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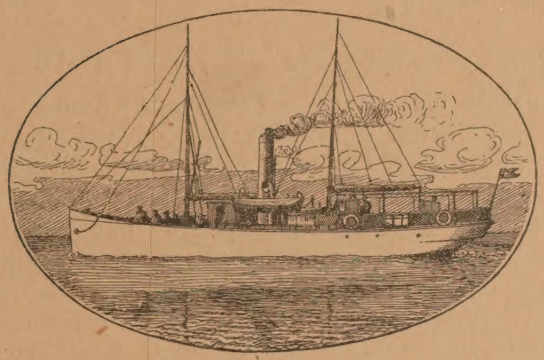
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XXIX.

1922.

By

C. G. Joh. Petersen,
Ph. D., L. L. D.
Director.

Copenhagen.
In Commission by G. E. C. Gad.
Centraltrykkeriet (C. Ferslew).
1922.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results, Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°, 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen.* Med Kort. 4°. 46 pg.

Fiskeri-Beretning for $18^{88}/_{89}$ til 1916.

Beretninger fra den danske biologiske Station findes paa dansk publiceret i de tilsvarende Fiskeri-Beretninger, til Beretning XXI med Tillæg. Senere udgives de som selvstændige Publicationer paa Dansk og paa Engelsk.

The Reports from The Danish Biological Station are also published in Danish in the corresponding Fiskeri-Beretning, until Report XXI with Appendix. Later on they are specially published in Danish and in English, but not in the Fiskeri-Beretning.

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II. Om vore Kutlingers *(Gobius)* Æg og Ynglemaade. (1891—92.) 9 pg. Med 2 Tavler.
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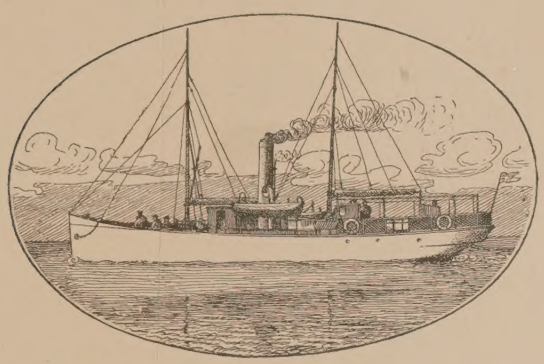

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On the Stock of Plaice and the Plaice Fisheries in different Waters.

A Survey

by

C. G. Joh. Petersen.

(With 2 charts and 1 appendix.)

1922.

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PREFACE

The main purport of the following is, that every important plaice-fishing necessarily affects the stock greatly in many different ways; the size-limit, the age, the growth-rate, the density, the annual production in kg, not to mention the appearance of the plaice, everything will change with the development of the fisheries. To obtain precise information as to the conditions of the different waters and to contrive the best possible annual production, that is the aim. The conditions can be very different in the different waters, yea in the different parts of the different waters.

The limited amount of food of plaice to hand at all times will restrict these efforts. A stock of plaice with a low growth-rate will not yield the same annual production as a stock with rapid growth; a very dense, slowly growing stock will give but a very poor yield, as almost all the food will go simply to the maintenance of life and next to nothing can be used for growing purposes.

The original conditions of the Sea do not as a rule seem to aim at the maximum of annual meat production but more at the forming of a dense stock. Human interests are others, i. e. as big an annual increase of plaice-meat as possible; we therefore try to change the original conditions in order to make them more suitable to our purposes, and we all agree now, that it is possible to influence the conditions through the fishing.

The relation between the stock of plaice and the fisheries at different times since 1893.

In 1893 when I wrote about the decrease of our flat-fish fisheries (Report from the Danish Biological Station IV, published in 1894) I had seen that a great change had taken place with the stock of plaice in the Kattegat and the Skagerak on account of the fisheries with Snurrevaad lately introduced.

I thought that this was the end of the golden day of the fishing industry as it was now impossible for a cutter with the usual outfit to take the same amount of plaice daily as before, and moreover the fish was smaller. The later developments proved me wrong.

In 1893 I presumed, that there was enough of young plaice near the coasts of the Kattegat and no danger of scarcity of old plaice for breeding purposes, but that the young plaice ought to be protected by a size-limit in order to let them reach a size that gave them market value, as was done by act of parliament in 1888 (Dansk Fiskerilov) though with a rather low size-limit.

This view of mine I called the »Theory of growth« as opposed the theory set up by several British investigators, that the prohibitive size-limit ought to be such as to allow the plaice to breed at least once before being caught. This theory, which I call the »Theory of propagation« aims principally at the increase of the number of small plaice. The prohibitive size-limit, the biological size-limit as it is called, compelled by the theory of propagation will as a rule surpass that corresponding to the theory of growth; abroad the wish was moreover for artificial hatching as a means of improving the stock while I took for granted, that we had plaice enough in our waters in 1893, and that first of all we should aim at making them grow to a reasonable market value, the request abroad was for a higher size-limit in order to allow more plaice to breed.

The theory of growth with its lower size-limit has proved convenient in most countries and has gradually become the prevailing theory; and if we do not follow this theory, it would be altogether impossible to fix a size-limit for the Eel, since it does not spawn in our waters. For species that spawn when the animals are still very small the theory of growth demands a higher size-limit than the theory

of propagation, but I shall not dilate upon this matter, the question being here only about plaice and how to get them of suitable market value before they are taken.

At this time the methods of investigations were not as good as they are now, still I began my marking experiments as early as 1888, consequently I knew about the great intensity of the fishing even at that time; for age-determination I had but my own self-devised collective mesasurement method which is usefull but for the very youngest age-groups, and statistics were in their infancy.

In 1895—96 I explored the Limfjord and in 1896 I published Report VI after having specially investigated the conditions in relation to the transplantation of young plaice from the North Sea to the Limfjord started by the fishermen in 1892; I saw, that where the plaice were but few pr. ha they grew quickly, where they were numerous they hardly grew at all. The first experiments with primitive bottom-samplers in order to investigate the amount of plaice-food at the sea bottom took place at that time and the idea of overcrowding was met with for the first time and an adress was sent to the Government requiring a greater annual transplantation af plaice from the overstocked to the understocked parts of the Limfjord. As is known these transplantations take place there every year and with good gain and are executed by the director of the fisheries, chiefly at the charge of the Government (App. I).

In 1899 J. Hjort and K. Dahl wrote about the Norwegian experiments with plaice fishing at the many small plaice grounds near the Norwegian coasts; they prove how easily the grounds are emptied of old plaice, so that several years must elapse before any profitable fishing can be undertaken again. They form the idea accumulated stock and are of the opinion that to these limited grounds the yearly immigration of young plaice is so slow and scarce, that fishing can only be carried on with an accumulated stock after several years. Yearly exploit is consequently out of the question at these parts; that is the case at least in many parts of the Norwegian waters; but the authors surmise, that the conditions of the North Sea are other.

In 1903 I wrote a little article »What is overfishing?« based upon our informations of that time, in which I acknowledge the idea of an accumulated stock and tranfer it to the conditions f. i. in the Kattegat; I advance moreover the idea, that when the accumulated stock has been taken in the Kattegat there would be better room for the young plaice so that they get more food and therefore grow quicker than they could before.

In 1905 H. Kyle proves my view on the decrease of the plaice fisheries in the Kattegat since ca. 1890 to be wrong according to the statistics in the later years, which show no decrease in the annual production in kg. His explanation is this, that first an accumulated stock needful of alteration has been fished up and that the current stock now grows quicker than was the case before; moreover the fishing intensity has grown by the increase both in the number of boats and in the fishing capacity of each boat.

Kyle was right in his assertion that I judged the conditions of the plaice fisheries wrongly in 1893, I did not make allowances for the technical evolution

enabling each boat to fish over a much greater area daily than before and therefore making it possible to keep the fishing going in spite of the alterations of the stock.

In spite of the greatly augmented fishing intensity the statistics did not show any progress in the total annual yield but showed about the same annual yield in the Kattegat during a period of several years. Besides fishing in the Kattegat many of the boats also fished in the Skagerak and the North Sea, the Kattegat alone being unable to provide for them.

In the following years Reibisch's Otolith-method for investigation of the age of plaice became extensively used, by means thereof precise investigations of the stock of plaice concerning growth, age etc. could be made, and in the years 1908—09 he himself made experiments concerning age and size for instance in the Baltic; about the same time A. C. Johansen explored the Belt Sea, the True Baltic and other Danish waters so that we know fairly well the conditions of the stock of plaice in the Belt Sea and in the Baltic in the years round 1908—09, both as to age and size.

In 1899 I introduced fishing by »Snurrevaad« in Great Belt and this kind of fishing soon had a rapid growth (see Report XXVII, 1920).

The old dense stock consisting chiefly of small, old plaice was fished up so that the stock became much less dense; but gradually the plaice got bigger on the average though much younger.

Now the fishing is persued chiefly on younger plaice but formerly mostly on older plaice. The density of the stock is now very sparse; where in former years we took 200—300 plaice in one haul with Snurrevaad we can now take but one plaice or two or none at all. Here I have virtually seen an accumulated stock fished up and replaced by a new one of younger but bigger fishes, to be sure not nearly as numerous pr. ha, but it is obvious that the stock is quickly renewed so that the statistics have been able to note good progress since 1899 in total production in kg, and the production has been kept up until this day in spite of great fluctuations from one year to another. (See table III).

With the tremendous increase in the number of Snurrevaad-boats in our southern waters since 1899 I feared in 1912 to see the ruin of the plaice fisheries there; but the many and extended areas of stony bottom in those waters have evidently been of great protection for the plaice; without them all plaice over 25,7 cm would certainly have been fished up, as is the case each year in the Limfjord, where fewer stone grounds of any importance can hinder the hauls with the seine.

It has been stated f. i. by Kyle that when the statistics show that now a cutter cannot take as many plaice daily as was the case in former years it does not prove any reduction in the stock of plaice, as more fishermen must now devide the same annual quantity (the total yield) and therefore each boat cannot get as much as before. Providing certain presuppositions this is true; if there are twice as many boats now and the total yield is the same, then each boat can only get half of its former daily catch. But when the fishing capacity of each boat has grown and yet each boat gets a smaller catch daily and in each haul, it indicates that the stock is less dense at the bottom of the plaicegrounds now

than in former days, there are at any stated time fewer plaice pr. ha, therefore they thrive better i. e. they grow quicker, they attain good market value in less time, are taken up and more quickly replaced by a new stock.

The density of the current stock is evidently a matter of great importance.

When the fishing capacity of each boat is small then the stock must be dense if the fishery shall be at all profitable. The density can be scarcer with the growing fishing capacity. The plaice seem to posess a particular power of preserving its productivity, be the stock more or less dense, yea they seem to be able to produce the same amount of plaice-meat pr. ha, the plaice growing quicker when the stock is less dense and slower when the stock is of greater density. We cannot help remembering that the plaice are maintained by the plaice-food available at the bottom and that it is the quantity of this food which settles the size of the production, within certain limits of course; as the stock can evidently be so small in number pr. ha that it cannot consume the available food and therefore at any rate dos not give the maximum annual production in kg possible for the water in question; just as the number can be so small that even the best outfitted boat cannot keep a profitable fishery going.

We are now better equipped for understanding the interaction between fishery and stock of plaice than in 1894; among other things we know, that in many waters the stock will stand intense fishing without being totally ruined, such as in the Kattegat and the Skagerak where the annual yield has been fairly kept up. In the Belt Sea we have seen the fishing improve the quality of the stock (the average size) and here too the annual yield has been about the same. We have seen that the endeavours in the direction of prohibitive size-limit have been of great value, [1]) by protecting the very young plaice so that they are not used for manure or cattle-food, [2]) by preventing too young and too small plaice being brought on the market and [3]) by protecting the stock in some degree.

We have seen that in the Nissum-Broad, where the plaice grow slowly, the prohibitive size-limit is of but small account in the keeping of the stock, these broad being over-crowded, but in the broads to which young plaice are transplanted high size-limits up to 29—30 cm has been of great value. Here the transplantation must be undertaken every spring, the stock being fished up every autumn, as here the plaice grow so quickly, that by then they are big enough. Here we have annual exploit; should we wait for natural immigration, the plaice fisheries in these waters would be of next to no importance. The reduced transplantation (on account of the high expenses, the number of plaice transplanted is by now halved) has reduced the yield of the fisheries in these waters to ca. $^1/_3$.

Lastly we have learned that we must be careful in assuming that the average size of the plaice in the different waters is an invariable magnitude. It depends very much upon the density of the stock and can therefore change by intense fishing, so that by different conditions the average size will change*).

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*) To compare a stock of plaice with a capital where only the interests may be used, as Heincke does it, is in my opinion objectionable and deceptive, the stock of plaice not being a sure capital, on the contrary the stock alters considerably by fishing; an accumulated stock, the

Based upon the Otolith-method we have series of determinations concerning the composition of the stock of plaice in different waters and at different times, giving good evidence as to several important points in the relation between fisheries and stock.

We have furthermore based upon our many fishing experiments with scientifical fishing implements, formed an estimate over the density of the stock of plaice in many parts of the Danish waters; see the sequel. To be sure it is difficult to state how many plaice live at a certain district of the sea pr. ha as we do not know how many are passed over by the fishing implements; but we can form an estimate over the relative density whether it is as in the Nissum Broad, where we take several hundreds of plaice in a haul of 10 minutes or if it is as in other areas, where we take but 10—20 plaice or 1—2. Furthermore this estimate of ours is continually verified through the landings of the professional fishermen, by looking at their hauls and by discussions when they fish alongside of us. I trust this kind of estimate and have consequently used the same construction and the same size of implements during several years in order to have a measure for the density of the stock of plaice at different districts and at different seasons.

The main characteristics in the biology of the plaice have long been explored; we know that the breeding plaice affect deep water abt. 30 m or more, but that the young in the bottom stage only live in very shallow water*) and thus have to migrate in order to gain full size. It is herewith proved that the size, form and whole topography of an area of water is of great importance in the maintenance of a large and quickly renewed stock of plaice. The Limfjord has no deep areas; this fact alone is enough to prevent the plaice from breeding there; the long and narrow passages from west to east make the immigration to the inner broads very hard particularly for the young plaice. (See the map App. I) The Belt Sea and partly the Kattegat and the Skagerak have but short distances from shallow waters to deep, therefore the stock is quickly renewed, the growth is rapid; near the coasts of Norway we miss big areas of shallow water, consequently there is but little room for the young plaice to grow, the North Sea is, compared to the waters above mentioned, of great extent, and the distances between the shallow water where the young plaice live and deep water is in most cases very great; this for one thing impedes the migration of the young plaice and consequently their growth. Had the Doggerbank been an island surrounded by shallow water, much would have had an other aspect; a lifting of the Doggerbank of abt. 10 m would highly improve the supply of young plaice in the North Sea as well as the annual yield; and the existence of other islands would be of

result of many years accumulation without touching the interests, is necessarily greatly affected when fishing begins. The density will diminish but the growth-rate will augment so that each individual fish will yield a greater production. If you want to use the metaphor of a capital, it must not be that of a tied capital, but of a capital gradually invested in papers bearing higher interests. Where the maximum production lies in difficult to say both for papers and stock of plaice, but the maximum production is our aim in both cases.

*) Only the True Baltic with its peculiar salinity conditions seems to form an exception from this rule.

equal value. It is therefore very questionable which areas of the North Sea can be kept up as actual plaice grounds with the present intense fishing, in the long run only those, to which the immigration takes place sufficiently quickly even if other areas, are otherwise adapted as plaice as grounds.

In my article »What is Overfishing?« in 1903 I mention several forms for overfishing, some rather curious; f. i. overfishing should be able to produce more plaice of certain age-groups than has been the case before, and we have seen many other peculiar consequences of intense fishing; in the future I will avoid the expression overfishing, as it is so very ambiguous, if we want to gain a clearer comprehension of the fate of the stock of plaice in the different waters we must use expressions of greater exactitude.

In the sequel I will try in few lines to give a discription of the conditions of the stock of plaice in the different waters within the Skaw.

The density of the stock of plaice in different waters.

I have in the years 1920—21 with a small-meshed implement with otter-boards a combination af the English Otter-trawl and the German Tog, made abt. 250 hauls each of abt. 10 minutes at many different places in Danish waters, this implement with meshes of about 15 mm from one knot to another giving excellent information as to the stock of fish at the valuated areas as it catches everything, eel, plaice, cod etc. and most of the fry of these fishes down to the very young ones only a few cm long. It is therefore a valuable implement by valuation investigations and is consequently much made use of; moreover many different places can be valuated in relatively short time as each haul with a fishing period of about 10 minutes takes including the time used for the lowering and hauling in of the implement only about 20—25 minutes.

Sometimes in a 10 minutes haul we have taken up to 200—300 cods of considerable size, abt. 500 small plaice, abt. 50 good sized eels etc. and lots of different fry, so that the fishing capacity of the implement in question is not bad in spite of its small spreading capacity, 8—10 m. By means of these 250 hauls we have been able to form a notion of the relative density of the stock of plaice at the different areas. In order not to enter too much into details I have made calculations as to the average number of plaice caught in our 10 minutes hauls in the different waters and I shall mention them here.

In the western parts of the Limfjord, in the Nissum Broad (See chart app. I) the average haul was of 293 plaice; in the inner broads this number goes down through 220, 114, 58, 19 to 1—2—3 and less plaice pr. haul in the areas into which plaice are transplanted, and shortly after the transplantation has taken place. Where we get 1—2—3 plaice in each haul a profitable fishery can be kept

up, if only the plaice are big enough i. e. above the size-limit. In the Kattegat and the Belt Sea we have found the average figure to be something very near those of the transplantation grounds i. e. abt. 6—5—4—3—2—1 or 0 plaice in each haul; only under the coasts in the Lesser Belt near Svendborg, in Nyborg Fjord and in Smaalandshavet we meet figures such as 11—12—21, but then we have to do with very young and small plaice very often far from the size-limit and therefore of no value for the fishermen. In the True Baltic east of Falster we have an average figure of 32 plaice, but these are also small plaice, mainly under the size-limit 25,7 cm and both young and old individuals.

With the exception of the areas where the young plaice (0-I group) appear near the coasts in the Belt Sea in a number of 11—21, the western Limfjord and the Baltic east of Falster, the density of the stock of plaice is very scarce all in all, and nowhere within the Skaw do we take more than 1—2—3 plaice above the size-limit*) in each haul but that enables the fishermen to take up to 20 individuals in each haul, with Snurrevaad and long lines, 600—800 fathoms. In the summer they may make about 10—12 such hauls daily and consequently take up to 10—12 scores of plaice daily, but often they get much less.

In the summer and the autumn 1921 we have seen boats with Snurrevaad fishing in the Aalborg Bay at the best plaice-grounds get abt. 20 plaice in each haul, plaice of abt 7 kg the score. In deeper water in the south-western Kattegat they frequently did not get more than 5—6—7—8 plaice in each haul but fish of abt. 9—10 kg the score.

When the density is so scarce everywhere, the reason is that where ever a stock of greater density is discovered the fishermen flock together in great numbers and in a short time the density is brought down to the usual minimum.

In 1899 before the Snurrevaad was introduced in the Great Belt I could as stated above with Snurrevaad and 300 fathoms of line take abt. 2—300 plaice in each haul, now I cannot take more than 1—2 or 0 plaice in each haul with the same implements.

According to the Fishing-Reports the ancient cutters with hand-winch and short lines, abt. 3—400 fathoms could in the Aalborg Bay take 60—80 scores of plaice daily in the years 1880—85 while the modern boats cannot take more than 10—12 scores, another proof of the alteration in the stock of plaice. Now as far as I can estimate the old boats could hardly take more than 1—2 scores daily. There is consequently an exceedingly great difference between the density of the current stock in the earlier days and now on the grounds suitable for seine-fishing.

The conditions described above are those of the summer time; in winter the old full-sized plaice appear to gather at certain deep grounds in the seas chiefly in the southern part of the Kattegat and in the Belt Sea, and the fishermen may at certain times make good hauls in the short winter-days. Evidently the

*) In the middlemost Limfjord, the density may, in the summer when seine-fisheries are prohibited, rise to 7—8 plaice of size-limit in hauls of 10 minutes.

plaice seek the deepest waters in the winter during the breeding time, not only from the grounds, where seine-fisheries are kept up in summer time i. e. the level bottom, but alse from the stony areas, where seine fisheries have no chance. Those stony areas form as a rule a great part of our sea-bottom, sometimes they constitute more than half the area and contribute therefore greatly towards the protection of the stock of plaice, which without them, as far as I can judge, would fare badly. When we know how eagerly the fishermen fish near the stones or between them, and the efficiency they show in finding even the smallest level ground between them, we understand, that only where the stones are close together and therefore prevent all fishing with the seine, the plaice can gain any protection.

Generally taken the density of the stock of plaice must be said to have decreased many times, but another great alteration has set in with our plaice fisheries since I published the chart in Report IV 1894; the center of gravity of the fisheries was then to be found in the northern Kattegat, at certain parts of the Aalborg Bay and in the eastern Kattegat, now apart from the northern Kattegat it is to be found chiefly near the coasts in the Aalborg Bay, and in the southern and south-western part of the Kattegat, in the Belt Sea and in the Baltic; the fisheries have thus to all extent and purposes changed location.

The age of the plaice, the age-groups which are the object of fisheries in different waters.

As the fishing-intensity evidently has had great influence on the density of the stock of plaice so the same has been the case as to the age of the plaice, in the first instance by removing all the old plaice from the fishing grounds.

In the Kattegat the great summer fisheries near the coasts of the Aalborg Bay is now the based solely upon individuals from group II i. e. plaice $2^1/_2$ years old; here they grow so quickly, that in August 1821 almost all individuals of group II were more than 25,7 cm; of older plaice there were none (Se table I and II).

In deeper water in the southern Kattegat the fisheries are based upon somewhat older plaice; in addition to group II, group III, IV and V make part of the catch.

In order to give a clear survey over the part of the stock of plaice that furnish material for our fisheries, we have on table I made a calculation over how great a percentage of full-sized fish above 25,7 cm each age group supplies; on the same table is furthermore stated the average size in cm of the individuals of the different age groups, both above and under the

size-limit, as well for males as for females. I shall later recur to this matter. All the statements from 1920—21 are the result of personal examination of plaice fished by our own hands or bought from the fishermen. The statements from the years before 1920 originate from the investigations of *A. C. Johansen* and *Reibisch*.

In table I for the Kattegat 1921 (column 2) it is seen that the fisheries in the Aalborg Bay are including solely group II — 100 %; — in deep water (column 4) group II—IV and older groups compose the catch, but the groups II—III with 22,1 and 50,2 % are the most important; all groups older than group V amount only to 2 %.

In the northern part of the Belt Sea, north of Funen and in the Great-Belt 1920—21 (column 5 and 7) in shallow waters we see that group II—III and IV take the leading part but in deep water the groups III and IV are paramount. Plaice above group V do not amount to more than 10,3 %.

In the Western Baltic in 1920—21 the bulk is belonging to group III—VI and with 16,3 % of older plaice.

Finally in the True Baltic in 1920—21 east of Falster, the bulk belongs to group V—VII besides which older groups amount to 28,0 %.

Here I do not take into consideration that the size-limit in force in the Western and in the True Baltic is not 25,7 cm but a little less; in this section it is more important to describe the stock of plaice than to settle the annual yield of the fisheries. Thus we know that the stock of plaice above 25,7 cm consists of older individuals and more so the further we proceed from the Kattegat towards the Baltic. It is a matter af course that this has not always been the case; from former days we know that very big plaice were caught both in the Kattegat and especially in the Skagerak, plaice up to 50 kg the score. And we have seen the stock in the Belt Sea change during the last years, particularly on the grounds where the fishing is most intense. The Snurrevaad was first rationally used in the Kattegat and the Skagerak, and then when the plaice grew scarce here it was made use of in the Belt Sea, where the poor quality of the stock of plaice had so far kept the fishermen away.

We have no age-determination of plaice for the years 1880—1890 but on table I are stated some from 1905—1907 and 1908—1909 and even on them we can see that the stock has undergone great changes since then.

On table II we have a detailed analysis of the growth of the younger age-groups in different parts of our waters. Among other things the table shows how the average size of an age-group can be below the size-limit of 25,7 cm and still partake in the annual fishing yield, because the computation of the average size of a group is based on all sizes — the smallest as well as the greatest individuals belonging to the group. — To this table II, I shall often refer in the sequel.

From the Kattegat we have no great material from former times in hand but what we have points towards the fact, that in shallow water 4—13 m Group III played a greater part than is now the case, and in deeper water 18—23 m the stock of plaice above group IV amounted to 39,5 % against now 13,6 %.

In the northern Belt-Sea, north of Funen and Great Bælt, table I (column

6—7) the age groups above group V amounted in 1907 to 64.5 % of plaice above 25,7 cm, in 1920—21 they did not amount to more than 10,3 %.

In the Western Baltic the groups older than group VI amounted in 1908—99 to 74,5 % now only to 16,3 %.

In the True Baltic the age groups older than group IX amounted in 1908—09 to 32,6 % now only to 14,7 %. Here the change has thus been less than in the other places; on account of the very poor quality of the plaice there has been no rational fisheries here until the latest years. There is no doubt that old plaice get more and more scarce where the fishery is intensive, and that the stock will be composed more and more of young individuals, at last quite paramountly.

The total yield in kg, the fishing intensity, growth rate, overcrowding etc.

When the stock of plaice has undergone so great alterations we should expect an enormous decrease in the annual yield in kg of plaice in these waters. In order to throw light upon this side of the matter, I shall refer to the accompagnying statistics (table III) for these waters, based upon the official reports to hand; for the year 1885—1910 from *A. C. Johansen*, for the following years directly from the fishing reports.

Statistics are a difficult matter to get thoroughly corresponding through series of years; and each seperate figure must be met with criticism, only the main point must be considered, which is here that the total annual yield in Kattegat and Skagerak has been kept up fairly invariable through the years at least up to 1915. It seems however as if the production has gone down in the Skagerak since 1913.

The total yield in the Belt Sea has increased steadily since the Snurrevaad came in general use abt. 1900, and the same has been the case in the Baltic during the last years.

While the plaice-fishing by foreigners is of comparatively small consequence in the Skagerak and the Kattegat, the Germans had important plaice-fisheries during the war in the western and the True Baltic; had their catch been added to the statistics, which only cover the Danish yield, the proficiency of these waters would have been still greater. But I know of no figure only passably fit for use from the German fisheries, I am therefore bound to keep entirely to the Danish statistics.

Though the fishing intensity has greatly augmented since 1890 both by an increase in the number of boats and by improvements in the outfit of each boat, thereby adding to its fishing capacity, the total annual yield in the Kattegat has not augmented but has been kept fairly unchanged as mentioned above.

How is this possible?

The great yields in 1885—1890 were undoubtedly caused by the fact that the small number of boats and their oldfashioned outfit i. e. hand-winch, no steam and no motors, had a dense stock to fisk from, an accumulated stock; later on the stock diminished, as we have seen and only the increase fishing capacity of each boat made further fisheries possible.

The remarkable feature in the matter is, that the productivity of the stock has, in spite of fewer individuals pr. ha, been able to yield the same annual production.

The way in which we fish here in Denmark — making it possible to set the small plaice caught in the nets out again while alive — together with our size-limit of 25,7 cm and the many stony grounds have been of great help towards preventing the impoverishing of the stock, but the dimished density pr. ha should alone, would it seem, end by giving a smaller annual yield. As far as can be judged the average size of the plaice has diminished somewhat since 1885, but the total annual production in kg has been fairly kept up.

There is but one explanation to this, i. e. that the individuals in the present now living stock of a small density grow quicker than those of the old stock of a greater density, so that now the stock is quickly renewed and consequently it has a great productivity, the results nearly corresponding to the production of the former days.

As matters stand now we possess but a few investigations concerning the growth rate of former days in comparison to the growth-rate of the present for plaice in the Kattegat; what I deem valuable will be found on the table I. There we find a calculation of the average size of the different age-grups in the southern Kattegat. In 1905 the group II showed in shallow water — 4-13 m — an average of abt. 24 cm as against 28,3 now; and in the deep water — 18-23 m — the average size of the groups II, III, IV was between 24,5 and 29 cm as against 31,1 to 39,3 cm now; and also the older groups seem now, at the average, bigger than in 1905.

An investigation in 1905 by *A. C. Johansen*, 146 plaice taken with Snurrevaad north of Anholt, showed a considerably greater growth than those taken with otter-trawl, the relation being about the same as in 1921. I shall not dilate upon this matter as far as the Kattegat is concerned, as we have during the latest years had better material to work upon in the Belt Sea. In Report XXVII, 1920 I have minutely elucidated this matter. Table I shows for these waters — in the columns: north of Funen and Great Belt, — 14-36 m — that the average size in 1907 for the groups II, III and IV was between 19,3 and 25,6 cm, but in 1920—21 the average size was between 25,2 and 34,7 cm, and the older groups have also now a higher average figure

In the Western Baltic the investigations of *Reibisch* from the years 1908—9 show that 1343 plaice taken with different implements and belonging to group IV and the groups above up to more than XI years had an average size of between 19,8—30,3, while 86 plaice taken with different implements in 1920 and belonging to group II and above, but as a rule much less than XI years old had an average size of between 28-37,7 cm. Though the number 86 be somewhat

small, I know that the material is fairly representative, having procured informations as to the catch of the fishermen in many places.

A comparison between the average size of the different age-groups in the True Baltic, Table I column 10—11, proves also that an alteration of the stock has taken place since 1908—09 tending towards a quicker growth-rate, even though not nearly in so pronounced a degree as in the other seas. Down here the density pr. ha is still much greater than in the Belt Sea and in the Kattegat.

It is thus beyond doubt, that the intensity of fishing, while diminishing the density of the stock in most of the Danish seas, has increased the growth-rate of the individuals, so that the productivity as a whole has been kept up, and the average size of the plaice in our southern waters is therefore larger than formerly.

It is difficult to state the fishing intensity, i. e. it is difficult to say how many % are taken annually of the bulk of plaice above the size-limit; we know, that of many marked plaice 80 % have been recaught, but this primarily applies only to the ordinary fishing grounds, not to the stony grounds; however no plaice will constantly stay at these grounds, they emigrate at times and are then an easy prey to the fishermen; still some plaice will always be left in the sea —, enough for breeding purposes, so that as a rule the fishing intensity cannot be 100 %.

Heincke has already called attention to the fact, that in the age of the plaice, we have a kind of measurement of the fishing intensity, the age will always decrease with a growing fishing intensity; and I shall add, that in the growth-rate we have another means of measuring the fishing intensity, about which I shall give further particulars in the following.

As will be remembered the western parts of the Limfjord had the greatest density of plaice in these waters, up to an average of 300 in a haul of 10 minutes, further investigations have yet to be made concerning the growth-rate in the Limfjord. In the western broad, the Nissum broad, we took on September 26. 1921 two hauls with »tog« each of 15 minutes, and the catch was in all 1190 plaice consisting of all groups from 0—V but no plaice were over 25,7 cm. A sample of those plaice will be seen in table II. With few exceptions they were all under 21 cm. In the spring, on April 25. 1921 abt. 1000 plaice were examined, with the exception of a few that were 27 cm all were of the same size and belonged to the same age-groups, thus the stock has continued through many years- numerous, dense, but with individuals of a very small size in proportion to their age; here next to no fishing takes place on account of the size being under the size-limit; sometimes there can be found a few more full-sized fishes but with regard to the stock in its entirety they do not amount to much. On table II, Aalborgbugten 1920—21, we see on the contrary a fishery based upon group II with individuals mostly above 25,7 cm. Here individuals from group I reach up to 24 cm thus being of the same size as group IV in the Nissum broad, but in the Aalborgbugt the density is 50 times less, than is usually the case in the Nissum broad i. e. 6 plaice in 1 haul of 10 minutes.

We see furthermore, that when small plaice from the Nissum Broad are transplanted in the spring f. i. to the Thisted Broad, they grow quite enormously during the summer months, here they are however transplanted far from each other with but small density abt. 50 individuals pr. ha at the most, corresponding

to abt 1—1—3 individuals pr. haul; any figure more precise cannot be given. That the Nissum broad is overstocked is beyond a doubt, I shall not dilate upon this, I have done it often enough. Between those two extremes i. e. the Nissum Broad and the Thisted Broad with overcrowding in the first (density 300) and in the second no plaice at all — except those transplanted — we find the conditions of the greater part of the rest of the Limfjord. Neither here shall I enter too far into the question, but only state that so the conditions have been since I made my first investigations in 1895 (Report VI 1896). In the Limfjord every plaice over 25,7 cm is taken every autumn and winter the fishing intensity is all but 100 %. The plaice do not breed in the Limfjord but immigrate in great numbers from the North Sea probably most of them while still belonging to group 0, but also as somewhat older individuals. They spread before being 6 years old, either by further immigration in the fjord, or by emigration back to the North Sea. When we consider the enormous difference of the growth-rate between the younger agegroups in the Nissum Broad and in the middlemost Kattegat, the question arises, whether we have not too few plaice pr. ha in the Kattegat.

Fig. 1.
20 cm ♀
IV-group (abt $4^1/_2$ year)
The Nissum Broad
$^{26}/_9$ 1921.

Fig. 2.
40 cm ♀
IV-group (abt. $4^1/_2$ year)
The Thisted Broad
$^{23}/_9$ 1921.

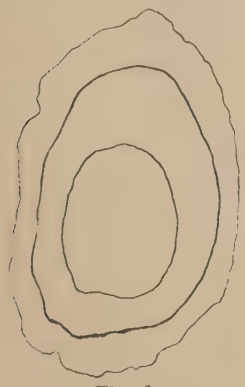

Fig. 3.
34 cm ♀ II-group
(abt $2^3/_4$ year)
16 ml. E. $^3/_4$ S. of the port of Grenaa $^7/_{12}$ 1921.

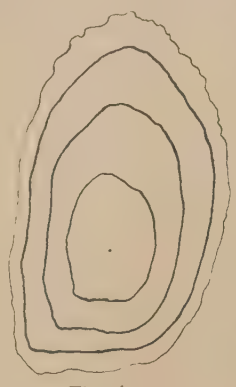

Fig. 4.
39 cm ♀ III-group
(abt $3^3/_4$ year).

The year-rings in the earstones (Otoliths) of the plaice are a valuable means of tracing the growth of each individual through the whole of its life. By comparison of two individuals of the same age, one of which has grown up in the Nissum Broad, and has been taken on September 26. 1921 (fig. 1), while the other (fig. 2) was transplanted from the Nissum Broad to the Thisted broad in the spring 1921 and taken here on the September 23. of the same year, it is seen, that both have the same number of growth-rings i. e. 4 + one still incomplete, but in the transplanted individual, the growth-ring corresponding to the months April—September 1921 is so big and broad as to make the surface measure of this earstone more than twice as large as that of the earstone from the individual not transplanted. The transplanted fish reached a total size of 40 cm while the other only measured 20 cm.

There is of course a certain correlation between the size of the earstones and that of the plaice, so that we can draw a conclusion as to the total size of the plaice by examining the earstones.

The figures 1—2 as well as 3—14 are drawn with the same magnifying power, 7 times, so that they can be used for comparisons. Those broad growth-rings in the transplanted plaice are for us an old and wellknown fact from the Limfjord.

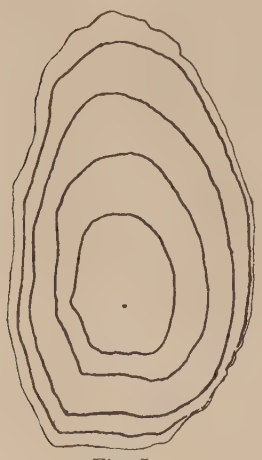

Fig. 5.
43 cm ♀ IV-group
(abt $4^{3}/_{4}$ year).

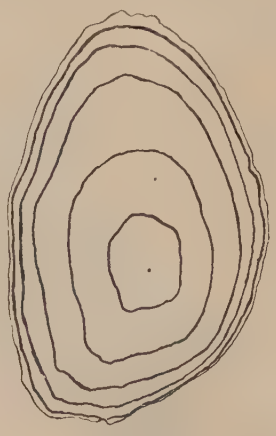

Fig. 6.
45 cm ♀ V-group
(abt $5^{3}/_{4}$ year).
16 miles E. $^{3}/_{4}$ S. of the port of Grenaa $^{7}/_{12}$ 1921.

The figures 3—6 show the quickly growing plaice from the southern Kattegat; compared*) to fig. 1 from the Nissum Broad we see, that the quick growth during the first 2—3 years is very conspicuous. Figure 6 shows that the growth from 4—6 years is less.

In the Western Baltic, where the stock, as stated above, consists chiefly of young quickly growing individuals, but also numbers a few old individuals, grown up during the years of low growth-rate, we see in the young and big ones earstones as shown in figs. 7—9

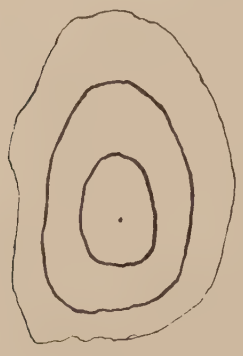

Fig. 7.
32 cm ♀ III-group
(abt. 3 years).

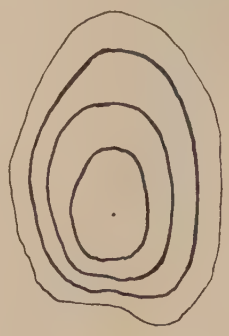

Fig. 8.
30 cm ♀ IV-group
(abt. 4 years).
Bagenkop $^{11}/_{5}$ 1921.

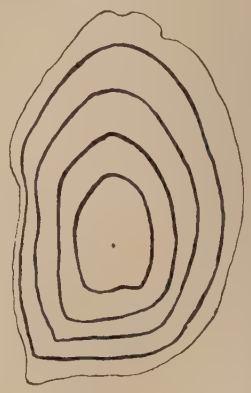

Fig. 9.
36,5 cm V-group
(abt. 5 years).

belonging to group III—IV—V with a total size from 30—36,5 cm, while the old and slowly growing plaice are represented by figs. 10 –12 respectively 9, 15, 18 years old and perhaps even older, but the total size of those individuals is abt.

*) In fig. 3—14 the middlemost of the white (opaques) growth-rings are indicated by black lines.

the same as that of the young plaice. However on almost all the figures 7—12 the first years growth is considerable; probably in the coastal parts, where only the youngest individuals are living, the overcrowding is not so great as in the deep waters where all the older plaice are living together.

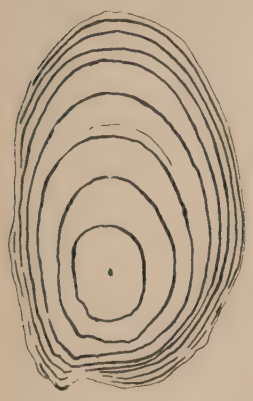

Fig. 10.
32 cm ♀ IX-group
(abt. 9 years).

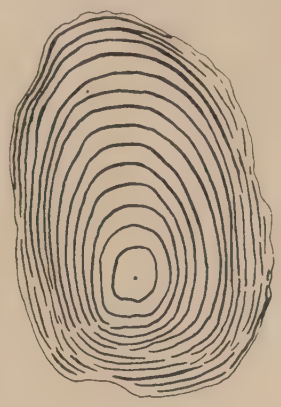

Fig. 11.
38 cm ♀ abt. XV-group (abt. 15 years).
Bagenkop $^{11}/_{5}$ 1921.

Fig. 12.
36 cm ♀ abt. gr. XVIII
(abt. 18 years).

In the True Baltic we also now find both types of earstones as is indicated by figs. 13 and 14; here also the growth in the first year seems to be considerable, at anyrate less restrained.

In the above I have tried to give a view of the conditions of the stock of plaice at different times with more or less intense fishing. I have tried to do it as well as possible, basing the view upon the statistical and biological investigations at hand. I could have wished far more complete material up through the years, but I have seen how difficult it is to make statistics giving exactly what is needed for later investigations concerning varying questions of research. I do not believe we shall get any nearer before each fisherman keeps an account over his catch and is bound in duty to hand it over for revision. Not even over the Limfjord can exact statistics be kept for the different broads, the boats going from broads to broads and fishing in them all. We must content ourselves with an estimate based upon approximate figures, which is always a help.

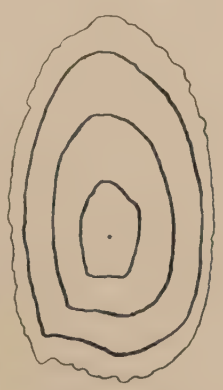

Fig. 13.
33 cm ♀ III-group
$3^{3}/_{4}$ years

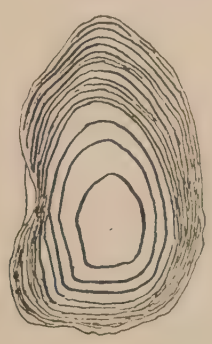

Fig. 14.
28 cm ♀ XV-group
above $15^{3}/_{4}$ years
15 miles S. E. to E of Møen $^{1}/_{12}$ 1921.

The biological investigations have other shortcomings; the precise methods have only been formed gradually, and suitable ships for the investigations have not always been to hand in sufficient time, and last but not least the war conditions have greatly impeded those investigations. This have been the conditions during the almost 40 years in which I have been occupated with the Danish fisheries. We must hope for better conditions in the next 40 years and I believe, they will improve, but we cannot afford to wait.

I have no doubt but that we can go far with the materiel at hand, when, as is the case here it is supported by experience, gathered in cooperation with the fishermen themselves during many years working with them at the fishing grounds. It would be easy to procure a much greater material of examined plaice f. inst. we could buy them from the fishermen. But I am of the opinion that we can be satisfied with the material at hand from 1920 and 1921; the quality of the investigations material being the main consideration whether big or small, and I think the material now before us is of high quality, our thorough knowledge of the fishing conditions making a good selection possible. Rather a small material of examined plaice rightly chosen, than a larger material chosen with less critique and competence.

I am convinced that in these investigations from 1920—21 we have a picture of the stock of plaice in the investigated waters clear enough to show a difference, if the future should bring any essential alterations as to age, growth, size and density in the stock of plaice in these waters.

Can anything be done in order to increase the annual yield of the stock of plaice?

It is an obvious question whether, considering the precent different conditions in the various waters, we get the best and the greatest possible yield from the stock of plaice, i. e. whether we get the yield, that these waters could give providing suitable measures were taken, the maximum yield. It would be rather astonishing were this the case, considering the different conditions and the almost unrestrained liberty reigning in most waters. Evidently this question can only be answered for each water separately, if any answer is possible. This shall be examined in the following.

In the Limfjord, where the Danish Government alone is legislator one would be apt to assume that the regulations of the stock of plaice, had gone far, in order to get the best annual yield, and this is also the case. In addition to the size limit, 25,7 cm for the whole of the Limfjord, we have rules about the opening date in the autumn for fisheries with plaice seines. But furthermore we have special regulations with a size limit of 30 cm and special protection for those waters into which transplantations are undertaken, and these

transplantations are carried through on as large a scale, as the available plaice-food warrants, and to all suitable grounds in the fjord.

When the statistics (see table III) show great fluctuations in the annual production in tons since the great transplantations were started in 1908, this is no doubt caused by the fluctuations in the quantity of plaice-food, and also in the last years of the war by a decrease in the number of plaice transplanted.

The natural immigration of plaice can no doubt, in certain parts of the Limfjord, influence the annual production to some extent, but the plaice-food at hand is without doubt a very important factor. The corresponding valuation investigations shall be passed over with but a few words, I must only be allowed to mention the fact, that the year 1921 shows a yield of 1113 tons from the plaice-fisheries in the Limfjord (se table III), a result that is much better than those from the 6 previous years, and more than twice the yield from 1920. At the same time our valuations have proved, that there was a much greater amount of plaice-food in 1921 than in the preceding years.

While thus the inner parts of the Limfjord yield about as much each year as is possible with yearly exploit, where all full-sized plaice are taken each autumn and winter, the western broad, — the Nissum Broad — is left more or less to itself with next to no fishery, as the plaice, though abt. 5—6 years old, have no market value on account of their small size. Further protection f. i. a size-limit higher than 25,7 cm besides the prohibition against fisheries with seines during the summermonths, as is now the case would be of no use here, where the growth-rate is very slow, and from where the plaice gradually emigrate. The very dense stock we have here is but of small use for the Nissum Broad, its importance lies in the fact, that it supplies other parts of the fjord and certain parts of the North Sea with young plaice, for the Nissum Broad itself the stock is of nearly no account.

If at any cost we want to get a bigger annual yield from this stock on the spot, we must remove many millions of plaice in order to give those left better room and thereby more food. The plaice now living in the Nissum Broad are underfed, proof there of being, that the local food-animals (*Abra*, *Solen*) are eaten up as young, and only those less coveted (*Corbula*) have any chance of reaching full-size. The question of overcrowding seems here a difficult question to avoid.

Out of consideration for the numerous fishermen living along the shores of the Limfjord mechanical powers are prohibited for fishing purposes, they are allowed for the propelling of boats, but not for the inhauling of fishing implements; trawls and such like big implements are absolutely forbidden. Likewise out of regard for the fishermen it has been found inexpedient to forbid all plaice fisheries during the summermonths f. i. are gill nets allowed. This is why so many transplanted plaice are caught and destroyed before they are full-sized i. e. abt. $^1/_2$ kg; larger they can hardly become from the spring to the autumn.

Annual exploit must be kept up, and that is one of the reasons why plaice above abt. $^1/_2$ kg (abt. 36 cm) cannot be produced in the Limfjord. This

is however a very good and valuable fish but far from all the transplanted plaice attain this size. The size varies ordinarily from 30—37 cm.

The weakest point in the utilisation of the stock of plaice in the Limfjord is thus the overcrowded Nissum Broad.

Conditions are quite otherwise in the Kattegat. We have nowhere here overcrowding i. e. slowly growing small plaice; naturally the fry is most numerous near the coast, particularly in the Aalbækbugt, but the growth is rapid; a higher size-limit than 25,7 cm would no doubt benefit the production in this water. Besides giving the plaice a greater value, it would allow them to spread themselves more over the other plaice-grounds; it seems to me, that the shifting of the main fisheries to the southern part of the Kattegat suggests, that the middle and perhaps the northern part are not now fully utilised by the plaice, because they are fished up near the coasts while still too young, and before they have had time to find the various places where food is to be found. The important center of the plaice fisheries in former years, north and south of Anholt has thus lost exceedingly in importance; in the '80's and '90's we saw the big cutters here in great numbers, although the want of the port subsequently built was very much felt.

I do not know the average weight of all the plaice taken in the Kattegat of late years, but during many years it was abt. 6—7 kg the score; we know however, that in shallow water, smaller plaice, abt. 4 kg the score and in deeper water larger plaice abt. 10 kg the score are taken, and as the growth of young plaice is rapid, we cannot doubt, that with a higher size-limit the production of the stock would greatly improve. The marking of plaice as practised by A. C. Johansen shows that the value of the recaught plaice though fewer in number is greater than the value of all the marked plaice; a more direct proof of the advantage of a higher size-limit can hardly be furnished. This happened before 1910 and I am of the opinion that the present conditions are still more in favour of a higher size-limit.

As early as in 1893 I advocated the introduction of a size-limit higher than 25,7 cm in the Kattegat, and what has happened since has only further convinced me, that it was a good advice. Abt. 30 cm is not too much for plaice in the Kattegat, and if it is introduced gradually in the space of a few years, virtually no inconvenience would follow; naturally the same size-limit must be maintained for the Swedish fishermen.

As is shown in table II, group II in spite of the higher size-limit could yet be the object of the fisheries, especially late in the year in the Kattegat (see also table I column 4). Similar conditions count for the Belt Sea and the Western Baltic, and should a number of plaice become a year older and belong to group III before being fished little harm would be done, as there is no fishery here to destroy them during that year, and overcrowding need not be feared. Of course the quicker a fish attains the size, that makes it fit for food, the less fish-food does it require to produce 1 kg of plaice-meat. But plaice between 3—4 years — group III — have always given satisfaction. Only in the Kattegat can a quicker growth be seen at present, according to my knowledge.

In the Øresund — down to Copenhagen — a similar size-limit would in

all likelihood be suitable; some investigations from the autumn 1921 imply that here also only quickly growing plaice are found at present. On the other hand our usual size-limit of 25,7 cm would be much to high for the True Baltic, east of Falster to Bornholm e. t. c. as the plaice here is of very slow growth, and the stock is rather dence; down there it would perhaps be better to introduce a size-limit still smaller, than the 22 cm now in force f. inst. 18 cm in order to get rid of all the small, old, slow-growing plaice, while the younger groups — 0—I—II —III — could still be somewhat spared. Should it then turn out, that the growth-rate improved very much — it has already improved somewhat in the last years — the size-limit could again be raised, as much as the growth-rate would warrant*).

*) Here I advocate quite another treatment of the stock of plaice in the Baltic than Heincke does (in Fischerboten VIII 1916); he is (pg. 187) of the opinion that the low growth-rate f. inst. in the Baltic is a real hereditary character of constitution, a race caracter for plaice in those waters, while I consider it possible to increase the growth, — to some extent at least, — by a thinning of the stock as we have done it for some years in the Belt Sea and in the Western Baltic, just by indiscriminating fisheries during the war.

Meanwhile I do not think, that the plaice in the Baltic will ever be as big as those of the Skagerak or the northern North Sea, which can reach to 90 cm in length, but even now the plaice in the Baltic can reach 45 cm in length; how many will be able to reach up to abt. 30—45 cm remains to be seen.

Heincke indicates l. c. pg. 188, that it has been proved, that plaice from the North Sea, transplanted to the Baltic grow quicker than the natives, and that the contrary is the case with individuals from the Baltic transplanted to the North Sea. This is however no deciding proof, as no allowance has been made by these transplantation experiments to the density of the stock on the grounds whereto transplantation was practiced, and neither has he, as far as I know taken the age of the transplanted plaice into consideration, some of the fishes being of an older group, from which the same growth-rate can not be expected as from younger ones. But even if the plaice from the North Sea have a somehwat higher growth-rathe in the Baltic than the native fish under the same conditions, this does not prevent the plaice from the Baltic getting a higher growth-rate when the stock is thinned. Of the hereditary qualities of the different plaice-biotypes in various waters we know nothing. Johs. Schmidt's fine experiments with fishes have taught us to be very careful in trusting in heredity of the number of fin rays. On the other hand we know, that plaice of the same race get a much higher growth-rate when transplanted from unfavorable to more favorable grounds for exemple to grounds that are not overcrowded. We are therefore entitled to hope for a speedy renovation and a quicker growth by a thinning of an old and dense stock, as has been the case in other seas.

It is easy to understand, that many have supposed hereditary differences among the plaice in our waters; the plaice of the old, dense stock in the Belt Sea and the Baltic having quite another appearance than the young plaice from the northern and middle Kattegat. Our fishermen have long asserted the great difference between the plaice fished north of and those taken south of Anholt and wondered at it. The plaice taken north of Anholt being big, smooth and fleshy, as a rule without any spawn or milt and, as I am able to add now young. Those taken south of Anholt were smaller, rough in the scales (shaggy said the fishermen) meagre often full of spawn or spent, with big red spots and big heads. The fishermen had their own name for those bright coloured plaice, they called them »parrot-plaice«. We now know, that they were only old plaice. The corresponding phases in the northern Kattegat and Skagerak of old and meagre plaice were the socalled »Hanser« or »Præsteflynder« (large plaice) they were often very large indeed, up to 2—3 kg each; they were soon exterminated. Now the »parrot-plaice« have also nearly disappeared from our waters except from the Baltic, and the difference between the plaice from the Belt Sea and those from the Kattegat is therefore not

As far as I can judge, the investigations of A. C. Johansen recommend the protection of great parts of the Danish coast of the Skagerak through a higher size-limit in co-operation with some of our neighbouring states.

If a suitably raised size-limit should be introduced in the Kattegat with or without the Skagerak, the question arises whether transplantation of plaice from overcrowded seas should not also be tried in addition. The nearest overstocked water is the Nissum Broad, and provided that the transplantation is first practised in the Limfjord itself in order to make it as densely stocked as desirable, the surplus could easily be transferred both to the Skagerak and the Kattegat. This may be a question for the future, but I will not leave it unmentioned here.

We have seen, that a size-limit as our present 25,7 cm (corresponding to the old Danish measure $9^3/_4$ inch) does not by far give the same average size in the different waters, as evidently the plaice are not caught exactly at the moment when they reach the length of 25,7 cm, most of them gain a somewhat larger size before being caught, the oversize depends partly upon the fishing intensity and partly upon the growth-rate; the first factor reduces the scale, the second one adds to it. In all waters the average size will surpass the size-limit somewhat; should the size-limit therefore be fixed at 30 cm, we might estimate the plaice we take at 33—34 cm at the average and the weight will thus be from 7,5—8 kg the score on the grounds where the smallest plaice are taken. Where stony grounds render further protection we shall certainly often find plaice of abt. 10 kg the score or even larger. In 1906 A. C. Johansen also advocated a size-limit of 30 cm for the Kattegat and the Skagerak, and he is of the opinion that probably the annual pecuniary profit of the fisheries would rise thereby with 50 or 100 %*). As stated before I am of the opinion that now

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nearly as marked as it was formerly. It was the poor food-conditions for plaice in some of our waters, that caused the dwarf-form; the thinning of the stock has now given good food-conditions and with that, greater similarity between the plaice of the different waters.

The naturalists have specially fixed their attention on the difference between the number of fin-rays and vertebrae of plaice in different waters and on the diversities of the otoliths especially whether these had many yearrings close together and were thickened or whether the rings were well separated and distinct with the the otoliths flat and showing good growth. Our investigations have however proved, that the appearance of the otoliths is completely altered by an altered growth-rate. This variation in appearance has nothing to do with hereditary characters of constitution, and we know nothing concerning the heredity of the number of vertebrae and fin-rays; it is a matter, that can only be investigated thouroughly by actual experiments, and I know of none such. Therefore as long as the question of hereditary differences is left open we must be careful not to believe too much in the existence of different races, and notably absolutely nothing can be inferred as to the growth-rate of the plaice under different circumstances, beyond what we know already i. e. that the growth-rate changes with different food-conditions.

As long as we do not know whether the plaice in the Baltic originate mainly from eggs drifting in from the Kattegat every year or whether the plaice from the Kattegat originate from eggs from the Skagerak or farther away, little should be said about heredity and races.

*) Johansen states, that plaice 26 cm in length have a weight of abt. 185 g and the price was then abt. 5 Øre, but plaice of 30 cm have a weight of 290 g and the price was 13 Øre. By raising the size-limit from 25 to 30 cm we shall gain a considerable increase in weight and

is the time to introduce a higher size-limit in the Belt Sea and the Western Baltic as well as in the Øresund down to about Copenhagen. Besides giving a more valuable fish the higher size-limit will accelerate the emigration to all the grounds suitable for plaice, and thereby benefit the production quantitatively; more over larger plaice can eat larger animals of the bottom-food than smaller plaice, and this fact will also cause the plaice-food to be better utilized than it is now.

I shall not dilate upon whether it is desirable to keep or to extend the present prohibition against the use of Snurrevaad on the young-fish grounds near the coasts, when we introduce the new size-limit of 30 cm, or whether an additional close season for those grounds would be of value during certain summer-months, it depends upon the future density of the fry at those grounds.

Here another thing must be mentioned, i e. the question whether there is sufficient fry in all these waters or in other words, whether there are enough spawning plaice, leaving the Limfjord out of question. This is difficult to decide, it would appear as if there was not too much fry in the Skagerak, the Kattegat and in the Belt Sea, the growth-rate being so enormous at some parts; if there is however not sufficient fry, the higher size-limit will supply the want, as by means thereof more plaice will reach the spawning stage.

It has always been difficult to be sure of the quantity of fry in the True Baltic, as it lives in deep water in contrast to its habit in other waters. The future will perhaps enlighten us upon this subject.

We have thus seen, that different measures are needed under different circumstances in order to get the maximum yield from the stock of plaice; the question often depends on a more or less correct estimate of what should be done in each individual case. We have now a fairly clear understanding of the rough lines on which to act. The problem is not the same unchanged through the times even in the same water; a constant change can be noted, and constant investigations of the conditions must therefore be kept going in order to keep pace with the changes.

During many years I did not consider it my duty to undertake such minute investigations, but conditions of the war made it necessary for me to take the matter up. The marine biological investigations have otherwise not been active during the war, but the matter is too important for Denmark to neglect. Investigations are however of little use if the fishermen interested in the question do not keep themselves informed of these matters, and in particular if they do not learn from the changing conditions and if they do not apply the scientifical results, among which the way to determine the age of plaice is one of the most important. Another result is, that we need not fear any immediate extermination of the stock of plaice in our waters, with great elasticity do the plaice adapt themselves to the intense fishing, but the difficulty lies in

about a three fold increased value; now the prices have changed, but the larger plaice have always a much greater value pr. kg than the smaller.

It is a matter of course that the higher size-limit cannot be introduced in the Limfjord as a whole, this fjord must have its own statutes.

getting the maximum production, and there we must have the co-operation of the fishermen.

In the Limfjord we have that co-operation where transplantation is concerned, and as has been stated before here Denmark alone has the right of legislation, but we have another big area of water where much could be done i. e. the waters from round Samsø to the east and west of Funen, and the more so now that we have regained part of the Slesvig. In this big water Denmark is virtually sole master of the plaice fisheries; I propose that something special should be done for these waters, partly by laws, and partly by transplantation if necessary. The plaice could then be taken from Esbjerg and transported over land to Lesser Belt, where boats could receive and distribute them where needed; but before any decision on this subject is taken, it would be advisable to wait and see whether the big production in kg will continue in the coming years.

By the introduction of a higher size-limit, such as 30 cm the difficulty will at once arice, that plaice between 25,7 and 30 cm have a considerable market value, while plaice under 25,7 are of next to no value, therefore the fishermen will be more tempted to evade the new law. The co-operation of the fishermen is necessary for the upholding of the law, before such a co-operation can be expected, it would be a mistake to introduce such a law. Another condition, that makes it difficult to control the enforcement of the law, is the fact, that the fishermen from Esbjerg are allowed to sell plaice of less than 30 cm down to 25,7 cm over the whole country. Fiskeridirektør F. V. Mortensen has called my attention to this fact. Should this consideration be of vital importance for the case, the old question of the introduction of a suitable size of meshes in certain implements for plaice-fisheries, specially in Snurrevaad and at least during summertime should be reconsidered. I foresee many practical difficulties, but it would be a pity should considerations of that kind prevent us seriously in our efforts to turn the productivity of our waters into better account than we do now.

In the preceding we have only discussed the treatment of the stock of plaice itself in our waters, but the thriving of the stock has also another side of importance. The sooner we get the fact before us, that it is strictly necessary to turn the amount of live plaice-food available at the bottom into account, the more we will see, that the animals which besides the plaice consume this food ought to be suppressed as much as possible when of lesser economical value than the plaice. There is first and foremost the common dab *(Pleuronectes limanda)* that in many of our waters compete with the plaice, and very often is to be found in very great numbers; in contradistinction to the plaice it dies very quickly when fished and cannot — like the plaice — be kept in well. Their lesser tenacity of life has probably kept their number down somewhat, but to throw the dead dab back into the sea is a mistake, as they then serve as food for many predatory animals such as crabs and star-fishes, gastropods e. t. c. which also devour the plaice-food. It would be better if we could find some profitable use for those creatures, so that it would pay to bring them to land and use them f. i. as manure. An apparently easy and cheap way of turning those animals to use has been mentioned by Otto Pettersson from Sweden. Could something of

that sort be done, and the dab together with other destructive animals thereby be more persecuted than they are now, much would be gained for the plaice. This is an old problem that for many years has been waiting for its solution. Perhaps modern technics may be able to overcome the difficulties. Every step taken towards the extermination or even the reduction of the destructive animals of the sea is of importance. I only mention the subject here in order to point out, that this side of the question ought to be considered, and that we should be prepared to seize the opportunity when a chance of forwarding the matter offers.

I have stated above my views as to the plaice-fisheries in our own Danish waters, among other things because it probably will be long before one and the same man again finds the opportunity of following this matter through so many years from 1883 to 1921. I am also tempted to state my view on the plaice-fisheries in the North Sea, but partly I am not so well acquainted with them as with our Danish plaice fisheries, and partly I presume that those, who have that matter in hand, will be able to draw their own conclusions from the present article — the principles suitable for the basing of a judgement on the conditions in the North Sea. However I wish to state here, that just as my original view of the treatment of the overcrowded Nissum Broad has undergone a change in the course of the years, my original view on the management of the overcrowded areas in the North Sea has done the same; more specially I feel the lack of information as to the importance of the destruction of immence numbers of young plaice group 0 and I by the shrimp-fisheries (Crangon) in the coastal parts of the North Sea. In the opinion of English authors it involves the annual destruction of thousands of millions of young plaice. Should I base my views on the stock of plaice of the North Sea on Heincke's report 1913 where he assumes, that the total stock of plaice above 12 cm amounts to abt. 1500 millions, of which only abt. 200 millions are used annually for human food, while further 300 millions are killed by trawl-fisheries, the number of the stock would seem to be more than sufficient, and plaice under 12 cm can be numbred in thousands of millions. In Heincke's prelim. Summary I 1913 pg. 50 it is stated that 1500 millions of plaice make an average of abt. 5000 individuals pr. km^2 on all the plaice grounds of the North Sea, or 50 individuals pr. ha; this is somewhat more than the number, we in Denmark consider suitable for transplantation to the richly supplied food-grounds of the Limfjord; did the plaice but grow as quickly in the North Sea as they do in the Kattegat or the inner broads of the Limfjord, where they grow big in a short time, everything would surely be first-rate. But it is obviously the growth-rate in the North Sea that leaves much to be desired, among other things because the distribution of the plaice is so unfortunate, there being too few, where they grow quickly and too many where the growth-rate is low. In both cases the remedy is transplantation on a large scale; if transplantation does not thin the stock sufficiently at the plaice-grounds, there is no other remedy than a still more intense fishery.

On account of the wide spread areas of deep water in the North Sea, it seems that there are enough plaice for breeding purposes in spite of the intense fishery. The relatively slow growth of the fry is not only the cause of much of

the food available at the bottom being used for the maintenance of life only and not for the production of flesh; the low growth-rate detracts further from the chance for the plaice of ever reaching any considerable size, as each added year detracts 33 % of those chances, this being after Heincke's opinion the annual fishing percentage.

Evidently a stock of plaice of a low growth-rate is very precarious to handle, its productivity being very much reduced on account of the reasons stated above, and it is very difficult to convert the stock into a quickly growing one. Up to now we have only done it with succes in some Danish waters by means of intense fisheries i. e. much thinning. Heincke writes in »General Report I 1913 pg. 20« that in the North Sea we find as a rule the largest individuals of any given year-group furthest from the coast. This may be due either to the fact, that they have grown quicker after emigrating or to the fact, that the larger individuals have a stronger tendency to emigration than the smaller ones, or perhaps both causes co-operate. It is therefore within reason to think, that by strongly thinning the fry-grounds the growth-rate could be raised, and a quicker emigration be the consequense. That a great many young plaice die is immaterial, if only a sufficient number emigrates or is transplanted and grows into full-sized fish. The common view, though I have not heard it asserted, is no doubt, that the more young plaice pr. ha on the grounds, the more and the quicker will they emigrate. This view is obviously transferred from purely human conditions, and it is far from sure, that it can also be applied to plaice.

It seems to me, that the treatment of the stock of plaice of each separate water must be undertaken from the point of view, that the aim should be to make the plaice consume the plaice-food available at the sea bottom in such a way that the greatest possible annual production of plaice-meat is assured. Consequently we must have 1) enough breeding plaice in order to guarantee sufficient fry, 2) enough of big plaice especially in the depths to consume the plaice-food that can only be devoured by larger individuals. The stock must nowhere be so dense as to impede the growth-rate, as in that case the plaice-food will mainly go to the maintenance of life, and not for meat production. Plaice will namely, even when not growing annually consume an amount of food representing 4—5 times their own weight, while the increase only claims its own weight once in form of food. A 7 years old plaice of 328 g has been twice as expensive to produce as one of the same size but only 3 years old, and as mentioned above, the slowly growing plaice have but a poor chance of ever reaching a suitable size, on account of the intense fishing. When plaice have reached their full size, and the growing stage is passed, it becomes expensive to let them live, as they consume much food simply in order to exist.

The idea of using the minimum amount of food for the maximum of annual meat production by having only quickly growing animals is the usual method in agriculture, and it seems to me to be of equal importance in the aquaculture, only here the practical efforts meet with greater difficulties, but without such a guiding idea

it seems almost impossible to find ones bearings in the many and complicated conditions of the fisheries, — even to understand and collect all the facts procured is difficult enough.

The above stated figures concerning the consumption of food by the plaice are taken partly from investigations as to the change of matter in fresh-water fishes made by the physiologists Aug. Krogh and R. Ege (Int. Revue d. ges. Hydrob. u. Hydrogr. Bd. VII 1915—16) and partly from personal observations on the daily consumption of the plaice in the Limfjord (Report XX from the Danish Biological Station 1911 pg. 61 ff.).

Table I.

The average size of the age groups of plaice from I and upwards. with infor

	The Kattegat.												North of Funen and					
Column:	1.			2.			3.			4.			5.			6.		
Depth:	4—13 m						18—23 m						4—17 m					
Month & year.	Septbr. 1905.			August 1921.			Septbr.—Novbr. 1905.			Novbr.—Dcbr. 1921.			Septbr. 1920 and Septbr. 1921.			March		190
Age-groups.		Average			Average			Average			Average			Average			Avera	
	%	♂	♀	%	♂	♀	%	♂	♀	%	♂	♀	%	♂	♀	%	♂	
I	0	19,9	19,9	0	19,3	19,3	0	21,8	—	—	—	—	0	18,6	18,0	0	14,4	1
II	52,9	23,5	24,8	100	28,4	28,2	16,5	24,5	26,0	22,1	31,1	34,2	53,3	26,1	27,2	2,1	19,3	2
III	47,1	26,8	30,2				37,4	25,9	28,4	50,2	33,9	37,6	26,7	31,4	30,0	14,6	22,5	2
IV							6,6	25,3	29,0	14,1	31,5	39,2	20,0	—	36,0	16,7	—	2
V										11,6	34,2	41,8				2,1	—	2
VI																		
VII										2,0	43,0	46,5						
VIII							39,5	28,7	34,1									
IX																64,5	30,1	3
X																		
XI																		
above																		
Number of individuals with age determination	67			116			151			199			68			150		
Of these plaice above 25,7 cm	17			28			91			199			45			48		

Notes to table I.

Column 1: A. C. Johansen (Ueber die Schollenfischerei im Kattegat und die Mittel sie zu heben. pg. 101. Ra ligth-buoy 12 m, and 9 miles E. S. E. of the light ship at Hals, 13 m. September 17—18 1905. 15

» 2: Danish Biological Station. Implement: eel-tog. Place: Aalborg Bay, the Tangen and off the Randers

» 3: A. C. Johansen (Ueber die Schollenfischerei im Kattegat und die Mittel, sie zu heben. pg. 104—105. 2) 3 miles from the light-ship at Svinbådan, 23 m. 3) 6 miles E. S. E. of Fornæs, 18 m. Septbr. 1

» 4: Danish Biological Station. Bought from the Snurrevaadsfishermen, no undersized fish caught. Place 7, 1921. 1 individual of uncertain age omitted.

» 5: Danish Biological Station. Implements: Eel-tog and otter-seine. Place: Nyborg Fjord. 1) S. of Slip

» 6: A. C. Johansen. (Om Rødspætten og Rødspættefiskeriet i Beltfarvandet. Skrifter. Komm. f. Havu 17—20, 1907. 38 individuals of uncertain age omitted.

» 7: Danish Biological Station: Bought 92 individuals from net and otter-seine-fishermen and caught the 21 m. 3) Deep hole near Lillegrunden, abt. 36 m. 4) N. of Funen, 14 m. Sept. 2—7, 1920 and Se

» 8: J. Reibisch (Biol. Unters. ü. Gedeihen, Wanderung, u. Ort d. Entstehung d. Scholle *[Pleuronectes plate* Region I + II (l. c. pg. 143) 3—29 m. August 1908—Oktober 1909.

» 9: Danish Biological Station. Bought from otter-seine fishermen. Caught by ourselves 10 individuals

» 10: J. Reibisch (l. c. pg. 168). Implements: Zeese, Stellnetz etc. Place: Region IV. (l. c. pg. 143), 8—1

» 11: Danish Biological Station. 105 individuals bought from a German Zeese fisherman, 169 individuals 17—19 m. 2) 15 miles E. S. E. of Hestehoved, 18 m. 3) 15 miles S. E. to E. of Møen, 24 m. 4-5 viduals of uncertain age omitted.

» 12: Danish Biological Station. Implement: Eel-tog. Place: Nissum Broad, 4—6 m. Septbr. 26 1921. 2

In some cases where it was doubtful whether an individual belonged to one or another of have been made by means of the otoliths.

n of how many % the different groups of plaice above 25,7 cm amount to.

he Belt Sea.									The True Baltic.						TheLimfjord			
Belt.			The Western Baltic.												Nissum Broad.			
7.			8.			9.			10.			11.			12.			
6 m			3—29 m			20—26 m			8—107 m			17—24 m			4—6 m			
eptbr. 1920 and Septbr. 1921.			August 1908— Oktbr. 1909.			August—Septbr. 1920.			August 1908 — Oktbr. 1909.			Septbr. 1920 and Aug.—Sept. 1921.			Septbr. 1921.			
	Average			Average			Average			Average			Average			Average		
%	♂	♀	%	♂	♀	%	♂	♀	%	♂	♀	%	♂	♀	%	♂	♀	
—	—	—	—	—	—	—	—	—	—	—	—	0	11,2	10,8	0	11,0	11,1	I
5,9	25,2	27,0	0	10,2	10,7	1,2	28,0	—	0	12,5	12,5	0	14,9	14,6	0	14,8	15,1	II
4,6	30,0	32,9	0	17,8	16,9	18,6	32,0	35,8	0	15,2	15,7	2,3	18,0	19,9	0	18,1	18,2	III
7,0	31,8	34,7	3,1	19,8	21,3	31,4	32,5	35,1	2,0	18,5	18,8	1,4	21,1	23,1	0	22,1	20,3	IV
2,2	—	34,0	6,6	20,4	23,1	12,8	33,0	36,0	0	19,2	22,1	18,8	21,6	28,3	0	24,0	20,0	V
6,5	31,0	33,9	15,8	21,5	24,0	19,7	29,5	34,8	8,9	21,6	23,5	18,8	20,9	28,8				VI
			20,6	22,0	24,6				19,8	22,6	25,2	30,7	23,4	30,8				VII
			15,3	22,6	25,4				16,9	23,1	25,8	8,3	27,2	31,9				VIII
3,3	31,0	40,4	16,7	23,9	27,0	16,3	35,0	37,7	19,8	23,7	27,6	5,0	27,0	32,5				IX
			8,8	24,9	27,0				13,8	23,5	29,6	2,3	24,8	33,0				X
			13,1	24,9	30,3				7,9	23,7	27,0	12,1	22,7	34,2				XI
									10,9	25,5	33,5							above
186			1343			86			584			694			407			
179			228			86			101			218			0			

Proc.-Verb. cons. perm. intern. Vol. V. 1906). Implement: ottertrawl. Place 8 miles N. N. W. of the Tangen
iduals of uncertain age ommitted.
Mariagerfjord, 4—8 m. August 29—30 1921.
p. et Proc.-Verb. cons. perm. intern. Vol.V. 1906). Implement: ottertrawl. Place 1) N. of Lille-Lysegrund, 22 m
vbr. 10 1905. 79 individuals of uncertain age omitted.
miles E. to S. of Yderflak, 23 m. 2) 16 miles E. ¾ S. of the port of Grenaa, 20 m. Novbr. 28 and December

, 15—17 m. 2) E of Palegrunden, 5—10 m. 3) Off Kalkovnsskoven, 5—8 m. Sept. 29, 1920 and Sept. 12, 1921.
Nr. 7. 1912 pg. 34—35). Implement: otter-trawl. Place: between Kerteminde and Tranekær, 14—17 m. March

urselves with eel-tog, 7 individuals caught with otter-seine. Place: 1) E. of Spodsbjerg, 13—15 m. 2) S. of Sprogø,
1921. 7 individuals of uncertain age omitted.
in der Ostsee. Wissensch. Meeresunters. N. F. 13 Bd. Abt. Kiel, 1911. pg. 168). Implement: Zeese, Stellnetz etc.

eel-tog. Place: 1) S. of Bagenkop, 20—23 m. 2) N. of Lyø, abt. 26 m. August 31 and Sept. 8, 1920.
August 1908 — Oktober 1909.
t from a Snurrevaad-fisherman. The rest caught by ourselves with eel-tog. Place: 1) 5 miles S. of Klintholm,
miles E. S. E. of Hestehoved, 22 m. Septbr. 11, 1920, August 20, Septbr. 14, and December 1, 1921. 6 indi-

iduals of uncertain age omitted.

successive age groups it has been entered on the table in the lower of the two groups. All age-determinations

Table II.

Survey of the growth of the younger age groups (I—III) in different waters.

	The Aalborg Bay.					Nyborg Fjord.					The Lesser Belt.					The True Baltic.					Limfjorden. Nissum Broad.				
	August 29—30' 1921					September 12 1921					September 9—10 1921					September 15 1921					September 26 1921				
	♂ – ♀					♂ + ♀					♂ · ♀					♂ · ♀					♂ · ♀				
cm	I	II	III	e*	total	I	II	III	e	total	I	II	III	e	total	I	II	III	e	total	I	II	III	e	total
8																									
9																1				1	5				5
10																2				2	33				33
11						1				1						2				2	66				66
12																3	6			9	28	7			35
13																1	18			19	5	17			22
14	2				2	1				1	2				2	1	21			22	2	26			28
15	2				2	2				2	1				1		18	2		20	1	27	1		29
16	6				6	1				1	3				3		20	5		25		33	11		44
17	8				8						2	1			3		14	8		22		11	29		40
18	7				7						2				2		4	9	1	14		3	37		40
19	13				13						3	2			5		3	10	4	17		1	26		27
20	11				11						3	3			6			6	6	12			12	10	22
21	12				12	1				1		8			8			3	4	7			8	2	10
22	9	1			10	1				1		7			7		3	3	2	8			1		1
23	3				3	1	1			2		12			12				1	1				2	2
24	1				1		3			3		6			6			1	1	2				2	2
25		5			5	1	3			4		6	3		9									1	1
26		5			5		1			1		4	2		6										
27		4			4		2			2		4	1		5										
28		3			3				1	1															
29		4			4																				
30		5			5		1			1															
31		3			3									1	1										
32		2			2																				
33		1			1																				
34																									
35																									
36		1			1																				
37																									
38																									
39																									
40																									
	74	34			108	9	11		1	21	16	53	6	1	76	10	107	47	19	183	140	125	125	17	407

Taken with Eel-tog by the steamer of the Danish Biological Station.

* e stands for elder individuals.

Table III.

Tons of plaice taken by the Danish Fishermen.

year.	TheLimfjord	The Skagerak.	The Skagerak and the Kattegat.	The Kattegat.	The Belt Sea.	The Baltic.
1885			5.272		433	
1886			4.549		404	
1887			5.940		487	
1888			3.463		622	
1889			4.267		666	
1890			4.523		708	
1891			3,926		729	
1892			4.536		617	
1893			3.812		532	
1894			4.539		546	
1895			5.317		561	
1896	c. 1.228		5.466		673	
1897	1.097		4.450		494	
1898	1.062		5.725		635	
1899	1.329		5.104		645	
1900	1.355		2.794		703	
1901	677		5.393		1.134	
1902	1.293		4.965		787	
1903	1.624		4.655		793	
1904	1.146		4.197		1.172	
1905	681		2.490		1.155	
1906	482		2.900		1.163	
1907	703		4.532		810	
1908	948		4.236		1.070	
1909	770	1.094	3.569	2.475	1.044	59
1910	864	1.044	3.708	2.664	1.467	61
1911	863	1.309	4.089	2.780	1.900	58
1912	734	1.244	3.923	2.679	3.494	28
1913	1.019	949	3.522	2.573	2.913	28
1914	1.371	673	4.447	3.774	1.615	28
1915	697	622	4.019	3.397	1.121	32
1916	664	451	2.556	2.105	1.073	42
1917	967	592	2.884	2.292	1.262	31
1918	544	303	2.443	2.140	1.354	33
1919	732	702	4.132	3.430	2.997	138
1920	528	759	2.909	2.150	2.380	179
1921	1.113					

Kort Nr 1.

CENTRALTRYKKERIET

APPENDIX I.

The annual transplantation of plaice in the Limfjord.

(With 1 chart and 1 table.)

The part of the Limfjord here in question (see the chart) goes from the canal of Thyborøn to Løgstør, the whole of the narrow eastern part is to be considered as a canal with next to no plaice fishery. The area is filled with shallow grounds, so that the plaice-grounds are of nò importance. By the Limfjord I therefore only include the stretch of water from Thyborøn to Løgstør with its various broads. Not until several invasions of the North Sea took place in the beginning of the 19' century and later, did the Limfjord become a fjord with salt-water, — 3 % to 2,5 % in the western parts, — with oysters, lobsters, plaice and other salt-water fishes; before 1825 mostly fresh-water fishes and brackish-water fishes were found there. Now the Government does its utmost in order to secure and uphold the western entrance partly on account of the shipping and partly on account of the fisheries. The fisheries being mainly or partly the means of a livelihood for a population of abt. 3000 fishermen. The main fisheries are after eel, plaice, cod and herrings besides oysters, lobsters e. t. c. The average depth of the Limfjord is only abt. 3—4—5 fathoms, the bottom consists of sand and clay with comparatively few stony grounds, so that hauls with seine can be carried on almost everywhere except near the shore. The tide is insignificant, the difference being of abt. 1 foot, and the current goes mainly from west to east, so that the salinity is very great. The fishing is very intense, and for several centuries the fjord has had its own laws, partly for settling matters between the fishermen concerning their many implements, and partly for the protection of the stock of the different species under changing conditions.

Plaice never breed in the fjord, I have never found pelagic eggs or larvae there; nevertheless there is on the whole enough plaice in the bottom stage and young fish. They enter the fjord through the Thyborøn canal and stand in shoals in the western broad — the Nissum broad. Here young plaice from the groups 0—V, but mainly under 26 cm length, can always be taken, during the winther months however with difficulty as they lie burrowed in the bottom, but from the first light days of April they can easily be taken in great numbers both with Snurrevaad and gill-nets.

The rest of the Fjord gets its supply of plaice from the Nissum Broad in a more or less natural way. The fishermen have long known, that even if the stock of plaice in the western broads were dense enough the individuals were never large, whereas plaice in the following broads — the Kaas Broad, the Sallingsund Broad e. t. c. — were larger but fewer, and that in the inner broads — the Thisted-Risgaard and Louns-Broad — they were so few, that no profitable fisheries could be kept going on them alone; but the few, that were caught from time to time were so large and valuable, that already in 1892 the fishermen from the Thisted Broad tried of themselves to transplant young plaice from the Nissum Broad to the Thisted Broad in order to make them grow. However this matter made no progress before it was supported by biological comprehension of the facts that 1) the plaice do not breed in the Limfjord, 2) the immigration to several of the inner broads is so slow, that the fishermen there fish them up with few exceptions before they attain valuable size.

My first impression, when I was on a short visit to the Limfjord in 1890, was that the western broads ought to be more protected f. i. by a higher size-limit than the 25,7 cm fixed by the law, then the plaice would, I thought, grow larger there, emigrate to the inner broads in greater numbers and there grow full-sized, but soon I learned to know better.

By my self invented marking method with bone buttons, it was proved (Report IV 1895) that the plaice grew very quickly when transplanted from the Nissum Broad to the inner broads f. i. the Thisted Broad where we find next to no plaice that have not been transplanted the same year, but that on the other hand they never grew large at all in the Nissum Broad even if they were 3—4—5 (even 6) years old. As a rule plaice above that age is not found in the Nissum Broad, they emigrate before — this the marking has proved — either to the North Sea or to the inner broads. Neither do they ever reach the breeding stage in the Nissum Broad. In the inner broads the transplanted or immigrated plaice do not get old either, being much coveted by the fishermen, so that almost all of them are fished up every autumn and winter, but they have then grown to such an extent as to weigh nearly $^1/_2$ kg. Here we have seen big ripe spawners with floating spawn, but they are not common. In the Nissum Broad, on the other hand, not nearly all the plaice are fished up every year, being so small, that by far the greatest number of them are under the Danish size-limit of 25,7 cm, and the largest of them are hardly above this limit; they are of but little value. Therefore the plaice-fisheries are chiefly carried on east of the Nissum-Broad and mostly during the autumn months, after they have grown big during the summer; but we have all kinds of graduations from the conditions of the Nissum Broad and those of the inner broads, both with regard to size and to number pr. ha. Their size in the autumn is always on the increase with the decrease of numbers.

When from the Danish Biological Station's steamer »Japetus Steenstrup« we trawl the Limfjord from west to east with the same implement, a sort of otterseine, it is easy to see, that the number of plaice fall off remarkably with each haul as we move towards east (see above pg. 12), such investigations have been made annually during many years. As we advance further in the fjord, we see the plaice increasing in size irrespective of age; there can be abso-

lutely no doubt about these facts. Besides we see that the natural immigration to certain of the midmost broads fluctuate in the various years, but it is not the number of plaice pr. ha that alone decides whether there will be god plaice fisheries; in the Nissum Broad f. i. the fishing on the whole is never good though there are many individuals pr. ha.

My first idea when I had mastered these conditions, was that perhaps the food-conditions were not as good in the Nissum Broad as in the inner broads. A preliminary investigation of the food-animals available on the sea bottom in 1895 proved however, that there was considerably of food on both places, and later valuation investigations through many years only confirmed this fact. No the reason of the undersized plaice in the Nissum Broad is evidently, that there are too many individuals pr. ha so that they have not got space enough and that they are consequently underfed, and the reason for the very high growth-rate in the inner broads is, that here we have but few individuals and therefore more food for the plaice. In other words the Nissum Broad is always overcrowded. In the following broads, the Lavbjerg-and the Kaas Broads e. t. c. where plaice in certain years grow but little more than in the Nissum Broad there has in these years been partly overcrowding, but in the inner broads —the Thisted, Risgaard and Louns Broads — there is always a scarcity of plaice, here they always grow quickly.

When I understood the conditions in question, I proposed to the Government, that it support the fishermen in their experiments at transplanting plaice from the Nissum Broad to the inner broads each spring, not as a trial to make them breed there, as was once the idea, but so as to make the plaice grow quickly in the Thisted Broad during the summer instead of their not growing at all or very little in the Nissum Broad. Then they could be caught as large, valuable plaice in the autumn and winter of the same year. In other words the proceedings should be the same as when the cabbage is planted out every spring over a greater area, so that each plant gets more room to spread and thereby increase in value. I proposed to take the small plaice from the Nissum Broad, partly because we had overcrowding there, and partly because it would be cheaper than taking them from the North Sea as had been formerly practised by the fishermen.

As the question of transplantation of plaice has become of special interest in the later years outside the Limfjord f. i. in the North Sea, I shall give a short survey over its development in the Limfjord during the years from 1892—1921.

From the statistics over these transplantations (pg. 43), which to begin with were only practised to the Thisted and Visby Broads (see the chart) we see, that the development has been steady, even as late as in 1896 the total yield of the plaice-fisheries only amounted to abt. 6000 Kr. and only abt. 10 tons were caught. When we started the more important transplantations in 1908, and at the same time raised the size-limit from 25,7 to 30 cm the total yield rose to more than 100 tons; about 40 individuals were then transplanted pr. ha. In 1909 60 individuals were transplanted pr. ha, and for a couple of years the yield rose to abt. 140 tons, but afterwards went down to 100 and 130 tons. Increased transplantations in 1915—1916 were of no use in 1916 the annual yield even went down to 67 tons. There is no doubt but that the transplantation in 1915—16

was too great, as the average weight pr. score in the autumn went below that of the good years. The average weight pr. score was in 1916 only $6^1/_2$ kg, in the good years it came up to 9—10 kg the score. Thus in 1916 many individuals did not reach the size-limit before the winter, and consequently a good deal were left over for 1917, when on account of the war no transplantation was performed at all, and therefore the annual yield in 1917 was not 0 but 27 tons.

At the urgent request of the fishermen the transplantations were resumed in 1918 and have been continued every year since, but on account of the prices, fewer are now transplanted. However the yield in Kroner has not for this decreased much.

The transplantations to the Thisted and Visby Broads have cost the Government abt. 5—6000 Kr. yearly, and the total annual profit has since 1908 reached abt. 100,000 Kr., so that it must be said to have been a lucrative investment.

Since 1908 transplantations have also been practised to other parts of the Limfjord, i. e. to the north-eastern parts of the Livø Broad and to the Risgaard and Louns Broads, but I regret not to be able to give any reliable statistical information with regard to the results of the transplantations in these waters, as it is nearly impossible to get any passably reliable information as to where the fishermen take their plaice; in their moterboats they rush from broad to broad in the course of one day, then again in certain years a considerable natural immigration goes on here especially to the middle parts of the Livø Broad, which results we cannot keep apart from those of the artifical transplantation. In this matter I have therefore decided to use as waters of experiment only the Thisted- and the Visby Broads with their more isolated position.

The Thisted- and the Visby Broads have had on an average an annual transplantation of abt. 500,000 individuals in the normal years from 1908—1916 ranging from 40—60 plaice pr. ha outside of the 3 fathoms curve at a price of from 5—6000 Kr. and with an annual yield of something more than 100 tons. The other waters to which transplantation was practised, and which together got abt. 4 times as many plaice ought cousequently to have yielded abt. 400 tons annually, but becauce the size-limit being lower here — only abt. 28 cm — and the conditions are not everywhere as favorable for the growth of the plaice, as they are in the Thisted Broad, the annual yield can hardly be fixed at 400 tons. If we fix it, say at 300 tons, and add the yield from the Thisted- and the Visby Broads, we get abt. 400 tons. The whole of the Limfjord yields abt. 900—1000 tons annually; consequently the parts, to which transplantation are not made produce more plaice than the transplantation areas. Especially Sallingsund with the south-eastern Livø Broad, the Kaas Broad and the waters round Venø have as a rule much the largest annual yield, while the Nissum Broad, in spite of its great extent only yield about 30—40 tons annually. The Kaas Broad and Sallingsund are in certain years the most productive fishing grounds, but the yield shows great fluctuations from one year to the other on account of the varying amounts of plaice-food to be found on the sea-bottom. Nowhere have we found such numbers of food-animals as in the Kaas Broad in 1917— of »*Solen pellucidus*« alone we found up to 170 g pr. 1 m^2 — and

in the autumn of the same year we had here an uncommonly rich result from the plaice fisheries. But it would lead us too far away to enter into the details of this matter; let it only be stated that because an abundance of plaice-food is found in one of the broads the one year, it does not at the same time necessitate abundance in the neighbouring broads. The amount of food-animals seems to depend upon local causes in these land-locked waters, just as the species seem to vary in the different broads, but without any knowledge as to the amount of food-animals available it is quite impossible to understand why the one year we have rich plaice-fisheries in certain broads, and at other times in others.

From statistics over the years 1899—1908 we see that only part of the transplanted plaice is reported recaught in the Thisted- and the Visby Broads — abt. $^2/_3$ of the total amount. This is caused chiefly by the fact, that out of consideration for the large number of fishermen, fisheries with gill-nets are allowed all the year round; so the transplanted plaice are perhaps caught many times before reaching the prohibitive size-limit abt. 30 cm, and many of them are destroyed in the nets by starfishes (*Asterias*) and gastropods (*Buccinum* and *Nassa*) which work havoc among the snared fish. On the other hand fisheries by Snurrevaad are prohibited during the summermonths from April 1. until late in the autumn.

The reason why the waters to which transplantation are practised do not admit of more than abt. 40 individuals pr. ha without a reduction of the growth-rate may be explained by the fact that just these waters have — in addition to the plaice — an important stock of eels which nearly consume the same kind of food as the plaice. The stock of eels is less dense in the waters to which no transplantation is made and this fact in connection with greater abundance of plaice-food contribute to the fact that by far the greatest part of the total annual production comes from these waters. In spite of its extent the Nissum Broad has — as stated above — but a very poor yield although there is an adundance of small plaice pr. ha.

It has long been on my mind to find a method by which it would be possible to give better information as to the actual number of plaice pr. ha than has been possible with the ordinary fishing-methods. By marking several thousands of the plaice transplanted to the Thisted Broad I have on subsequent fishing in the broad found the same percentage of marked plaice among those caught, as among the transplanted plaice; and I think this proves that these waters contains pratically no other fish than those transplanted there, but no native stock; however I have only approximated the real number of plaice pr. ha in the Nissum Broad. I have come to the conclusion, that with-uniform implements (tog with otters) we can on an average in the Nissum Broad take abt. 300 plaice in 10 minutes as against 1—2—3 in the Thisted Broad. Therefore if there are abt. 50 plaice pr. ha in the Thisted Broad there must be at least 100 times as many individuals pr. ha in the Nissum Broad, but the figures from the Thisted Broad are not reliable enough, the many gill-nets impeding a thorough trawling of the whole area. However I do not doubt, that there are many millions of plaice in the Nissum Broad, with their plaice-grounds of at least 11,000 ha — perhaps abt. 50 times 100 times 11,000 = 55 millions, besides the

groups 0 and I at the shallow grounds, or abt. 5000 plaice pr. ha, however this figure is not to be relied upon.

In the autumn it is interesting to compare the *otoliths* of a plaice transplanted to the Thisted Broad in the spring, to otoliths from a plaice of the same age from the Nissum Broad (see fig. 1 and 2 pg. 19). We note an immense growth in the last ring of the otoliths of the transplanted plaice which total length was abt. 40 cm, but only a very small growth-ring in the otoliths of the plaice from the Nissum Broad and, though of the same age — $4^1/_2$ years — the plaice did not measure more than 20 cm. It is easily seen whether a plaice has lived one or two years in the inner broads; it has then one or two large growth-rings, which is never the case with a plaice in the Nissum Broad. Heincke has (Der Fischerbote VIII Jahrg. 1916 pg. 117) drawn such an otolith from a plaice that I had sent him from the Thisted Broad, he claims thereby to have proved »scientifically« the high growth-rate of transplanted plaice; this is so far right, but the increased lenght of the marked plaice has long before shown this and the fact, that the growth can also be seen on the otoliths has long been commonly known, at least here in Denmark.

The plaice used for the purpose of transplantation are taken from the western parts of the Nissum Broad*) with Snurrevaad and from small open boats, they are carried in welled boats — preferably motor boats — to the inner broads, where they are distributed over the whole area. The fishing of abt. 2 millions of plaice does not take more than a few days in April; as a rule the number of welled boats decide the duration of the transplantation — 4—5—6 days is the usual time — and no decrease can be noticed in the stock, though the area is gone over many times, no plaice under ca. 16 cm are used for transplantation and few above 26 cm. They weigh from $1^1/_2$ to 2 kg the score. Very often in November the plaice transplanted weigh up to 9 kg the score, they have consequently doubled their weight 4—5 times in little more than half a year and grown abt. 12—15 cm; but in the Nissum Broad there is next to no change in the size of the plaice from spring to autumn, their growth is quite insignificant. The plaice used for transplantation belong to the groups II—V, most ofthern to the groups III and IV.

*) See the chart at R.

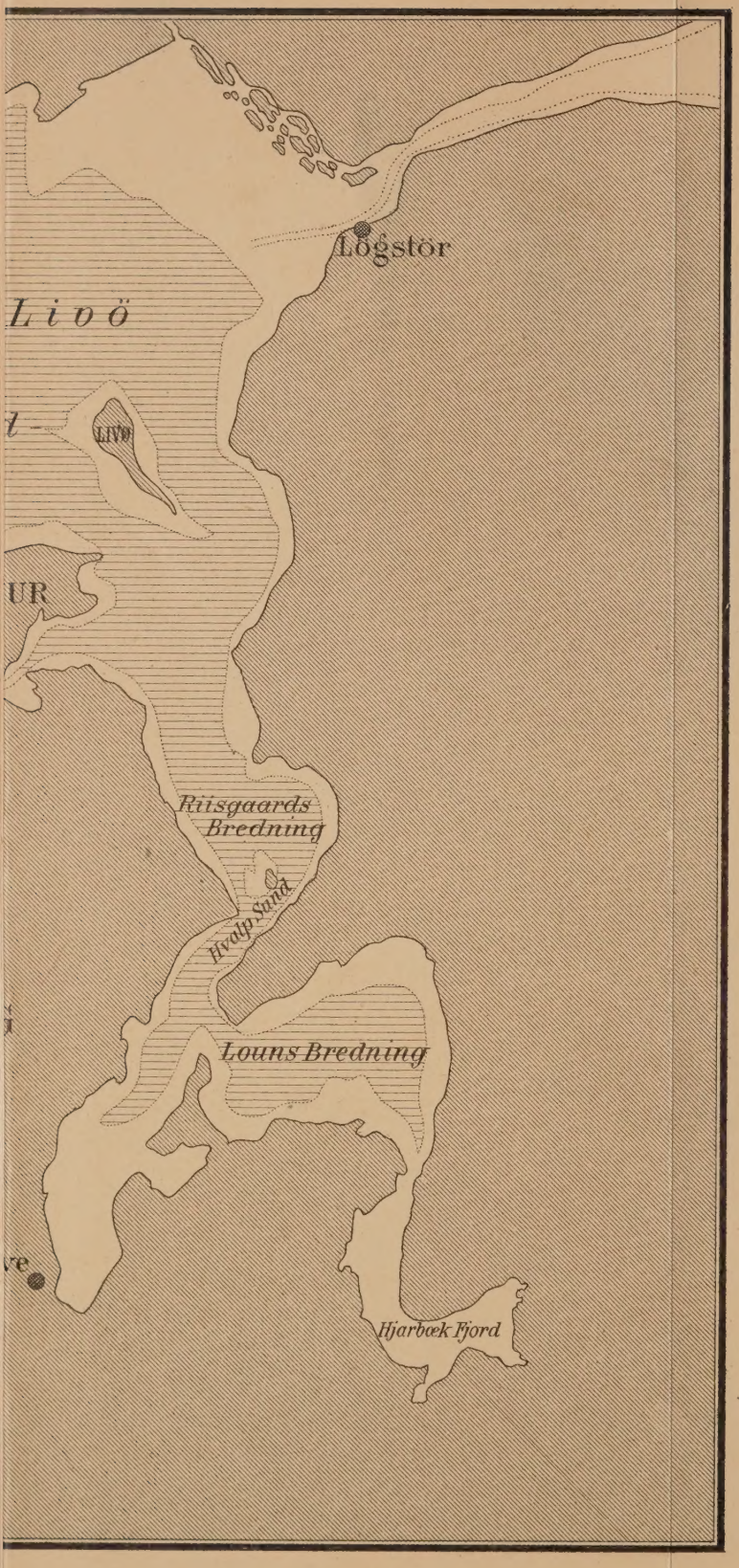
App. I table I.

Statistics over the plaice-fisheries in the Thisted- and Visby Broads in the Limfjord.

year.	transplanted.	recaught.			
	1000 Indv.	1000 Indv.	tons.	1000 Kr.	
1892.	7				
1893.	50				
1894.	70				
1895.	83				
1896.	54		c. 10	c. 6	
1897.	108			11	
1898.	99			12	
1899.	107	c. 70		17	
1900.	196			22	
1901.	127	87		23	
1902.	142	81		15	
1903.	c. 110	79	35	19	
1904.	115	47	21	14	
1905.	116	66	30	18	
1906.	137	101	45	29	
1907.	127	95	42	28	
1908.	372	254	102	67	Important transplantation was started in 1908.
1909.	c. 550		149	98	The size-limit was raised from abt. 26 cm to abt. 30 cm.
1910.	»		142	91	
1911.	»		100	64	
1912.	»		119	71	
1913.	»		113	74	
1914.	»		129	78	
1915.	c. 689		122	102	
1916.	»		67	81	
1917.	0		27	32	
1918.	251		33	42	
1919.	338		38	72	
1920.	318		37	73	
1921.	318		41	62	

PARTI AF LIMFJORI
(PART OF THE LIMFJOR

EN.
D.)

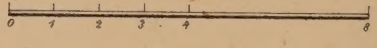


3 Favne Kurve. (3 Fathoms curve)

Arealer hvortil Rødspætter omplantes.
(Areas to which plaice are transplanted)

Indenfor denne Grænse ɔ: paa Arealet R i Nissum Bredning, indfanges sædvanligvis alle Rødspætterne til Omplantning.
(Within this limit, i.e. upon the area R in the Nissum Bredning, all the plaice are usually caught for transplantation)

Maalestok: Kvartmil.
(Scale: Miles.)



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